

## CLAIMS

### What is claimed is:

1. A method of reducing network congestion comprising the steps of:  
transmitting multiple packets from a sending node to a receiving node over a network communication medium at a rate no faster than a predetermined maximum packet transmission rate value;  
receiving multiple acknowledgements at the sending node from the receiving node;  
measuring a transmission performance value based on transmission of a packet of said multiple packets and a corresponding acknowledgment of the multiple acknowledgements;  
predicting an available bandwidth value based on at least two transmission performance values; and  
adjusting the predetermined maximum packet transmission rate based on the predicted available bandwidth to reduce network congestion on the network communication medium.
2. The method of claim 1 wherein the step of predicting comprises:  
determining a polynomial equation based upon the at least two transmission performance values; and  
extrapolating from the polynomial equation to determine the predicted available bandwidth value.
3. The method of claim 2 wherein the step of determining comprises:  
determining a cubic spline function based upon the at least two transmission performance values.
4. The method of claim 1 wherein the step of measuring comprises:  
determining a time interval between a first transmitted packet and receipt of a corresponding acknowledgement message as the transmission performance value.
5. The method of claim 1 wherein the step of measuring comprises:

counting a number of additional packets transmitted between a first transmitted packet and receipt of a corresponding acknowledgement message as the transmission performance value.

6. A method for reducing re-transmission delays in a packetized network protocol comprising:

measuring a time between a successful packet transmission and receipt of a corresponding acknowledgement;

using the measured time as a timeout value for a subsequent packet transmission;

detecting expiration of the timeout value following the transmission of said the subsequent packet; and

retransmitting the subsequent packet in response to detecting expiration of the timeout value.

7. The method of claim 6 further comprising:

detecting receipt of two negative acknowledgement packets,

wherein the step of retransmitting is further responsive to the detection of receipt of two negative acknowledgement packets.

8. A method for reducing TCP/IP network congestion comprising:

estimating available bandwidth on the TCP/IP network based on a positively acknowledged packet; and

responsive to the estimated available bandwidth, dynamically adjusting at least one TCP/IP transmission parameter to reduce packet loss due to network congestion.

9. The method of claim 8 wherein the TCP/IP parameters may include one or more of slow start threshold, congestion window and roundtrip time.

10. The method of claim 9 wherein the step of estimating comprises:

determining a number of additional packets transmitted between a first transmitted packet and an acknowledgement message received corresponding to the first transmitted packet.

11. The method of claim 9 wherein the step of estimating comprises:  
determining a time interval between a first transmitted packet and an  
acknowledgement message received corresponding to the first transmitted packet.

12. The method of claim 9 wherein the step of adjusting comprises adjusting  
the roundtrip time.

13. The method of claim 12 further comprising:  
applying the adjusted roundtrip time to reduce retransmission delays on the  
TCP/IP network.

14. The method of claim 13 wherein the step of applying comprises:  
detecting expiration of the roundtrip time following transmission of a packet  
without receiving an acknowledgement; and  
retransmitting the packet in response to detection of the expired roundtrip  
time.

15. A system comprising:  
a packet network communication medium;  
a first network appliance communicatively coupled to the medium; and  
one or more other network appliances communicatively coupled to the first  
network appliance via the medium,  
wherein the first network appliance further comprises:  
a predictive tuning element to dynamically predictively adapt protocol  
parameters of the first network appliance based on present and past measurements of  
throughput on the medium.

16. The system of claim 15 wherein the predictive tuning element further  
comprises:  
a congestion avoidance element to dynamically adapt transmission protocol  
parameters to avoid congestion on the medium.

17. The system of claim 16 wherein the first network appliance is a TCP/IP  
protocol compatible network appliance and wherein the congestion avoidance element

dynamically adapts the cwnd TCP/IP parameter to avoid congestion based on current and past measurement of throughput applied to a predictive mathematical model.

18. The system of claim 17 wherein the predictive mathematical model fits a cubic spline polynomial to the present and past throughput measurements to predict future throughput and corresponding adaptation of cwnd.

19. The system of claim 15 wherein the predictive tuning element further comprises:

a retransmission element to dynamically adapt retransmission protocol parameters to reduce latencies associated with detecting packet loss on the medium.

20. The system of claim 19 wherein the first network appliance is a TCP/IP protocol compatible network appliance and wherein the retransmissions element dynamically adapts the RTT TCP/IP parameter to reduce latencies based on current and past measurement of throughput applied to a predictive mathematical model.

21. The system of claim 20 wherein the predictive mathematical model fits a cubic spline polynomial to the present and past throughput measurements to predict future throughput and corresponding adaptation of RTT.

22. A computer readable storage medium tangibly embodying program instructions to perform a method of reducing network congestion, the method comprising the steps of:

transmitting multiple packets from a sending node to a receiving node over a network communication medium at a rate no faster than a predetermined maximum packet transmission rate value;

receiving multiple acknowledgements at the sending node from the receiving node;

measuring a transmission performance value based on transmission of a packet of said multiple packets and a corresponding acknowledgment of the multiple acknowledgements;

predicting an available bandwidth value based on at least two transmission performance values; and

adjusting the predetermined maximum packet transmission rate based on the predicted available bandwidth to reduce network congestion on the network communication medium.

23. The storage medium of claim 22 wherein the step of predicting comprises: determining a polynomial equation based upon the at least two transmission performance values; and extrapolating from the polynomial equation to determine the predicted available bandwidth value.

24. The storage medium of claim 23 wherein the step of determining comprises: determining a cubic spline function based upon the at least two transmission performance values.

25. The storage medium of claim 22 wherein the step of measuring comprises: determining a time interval between a first transmitted packet and receipt of a corresponding acknowledgement message as the transmission performance value.

26. The storage medium of claim 22 wherein the step of measuring comprises: counting a number of additional packets transmitted between a first transmitted packet and receipt of a corresponding acknowledgement message as the transmission performance value.

27. A method for reducing re-transmission delays in a packetized network protocol comprising:  
measuring a time between a successful packet transmission and receipt of a corresponding acknowledgement;  
using the measured time as a timeout value for a subsequent packet transmission;  
detecting expiration of the timeout value following the transmission of said the subsequent packet; and  
retransmitting the subsequent packet in response to detecting expiration of the timeout value.

28. The method of claim 27 further comprising:  
detecting receipt of two negative acknowledgement packets,  
wherein the step of retransmitting is further responsive to the detection of  
receipt of two negative acknowledgement packets.